Launch Sites Locations Analysis with Folium

Estimated time needed: **40** minutes

The launch sites near Florida or California, both on coastline lines, with large and rail or, it may also depend on the proximity of railways and highways. Launch sites must be far from the city to avoid any accidents, launch sites should be near to the equator and relatively close to highways and railways for ease of transport. Launch sites should be near to the coastline to ensure that any launch failures do not cause any harm to the public.

In the previous exploratory data analysis labs, you have visualized the SpaceX launch dataset using `matplotlib` and `seaborn` and discovered some preliminary correlations between the launch site and success rates. In this lab, you will be performing more interactive visual analytics using `Folium`.

Objectives

This lab contains the following tasks:

- **TASK 1:** Mark all launch sites on a map
- **TASK 2:** Mark the successful/unsuccessful launches for each site on the map
- **TASK 3:** Calculate the distances between a launch site to its closest proximities

After completing the above tasks, you should be able to find some geographical patterns about launch sites.

Let's first import required Python packages for this lab:

```
!pip install folium pandas==1.1.5
!pip install wget
import pandas as pd
import numpy as np
import wget
import folium
from folium.plugins import MarkerCluster
from folium.plugins import MousePosition
from folium.plugins import DivIcon
from folium.plugins import AntPath
```

If you faced ti difficult plan theatics about folium, you may download and refer to this previous folium lab:

Generating Maps with Folium

Task 1: Mark all launch sites on a map

First, let's try to add each site's location on a map using site's latitude and longitude coordinates

The following dataset with the name `'spacex_launch_geo.csv'` is an augmented dataset with latitude and longitude added for each site.

```
# download the dataset
spacex_launch_geo = 'https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/spacex_launch_geo.csv'
spacex_df = pd.read_csv(spacex_launch_geo)
```

Now, you can take a look at what are the coordinates for each site.

```
# Select relevant subset of columns
spacex_df = spacex_df[['Launch Site', 'Lat', 'Long']]
spacex_df.groupby("Launch Site").count().reset_index()
```

Launch Site	Lat	Long
0 CCAFS LC-40	26	26
1 CCAFS SLC-40	55	55
2 KSC LC-39A	22	22
3 VAFB SLC-4E	13	13

Above coordinates are just plain numbers that can not give you any intuitive insights about where are those launch sites. If you are interested in knowing those launch sites' locations on a map, then visualization is a good way to go. To do so, we first need to import these locations by adding them as markers.

We first need to create a folium `Map` object, with an initial center location to be NASA Johnson Space Center at Houston, Texas.

```
# Start location is NASA Johnson Space Center
nasa_coordinate = [29.559684, -95.0830255]
site_map = folium.Map(location=nasa_coordinate, zoom_start=10)
site_map
```

and you should find a small yellow circle near the city of Houston and you can zoom in to see a larger circle.

Now, let's add a circle for each launch site in data frame `launch_latlong`

TODO: Create and add `folium.Circle` and `folium.Marker` for each launch site on the map

An example of folium Circle:

```
folium.Circle([29.559684,-95.0830255],radius=1000,color='#000FF',).add_to(site_map)
```

An example of folium Marker:

```
folium.Marker([29.559684,-95.0830255],icon=DivIcon(icon_size=(20,20),icon_anchor=(0,0),html=' 
CCAFS LC-40',),popup='CCAFS LC-40',).add_to(site_map)
```

```
# TODO: Create and add folium.Circle and folium.Marker for each launch site on the site map
# For the first site, I'm using the coordinates of CCAFS LC-40
# for i in range(len(launch_latlong)):
#
#
#
site_map
```

The generated map with marked launch sites should look similar to the following:

Now, you can explore the map by zoom-in/out the marked areas, and try to answer the following questions:

- Are all launch sites in proximity to the equator line?
- Are all launch sites in very close proximity to the coast?

Also please try to explain your findings.

Task 2: Mark the successful/failed launches for each site on the map

Next, let's try to enrich the map by adding the launch outcomes for each site, and see which sites have high success rates. Recall that data frame spacex_df has detailed launch records, and the `class` column indicates if this launch was successful or not

```
spacex_df.tail(10)
```

	Launch Site	Lat	Long	class
46	CCAFS LC-40	28.56194	-80.577366	0
47	CCAFS LC-40	28.562302	-80.577366	0
48	CCAFS LC-40	28.562302	-80.577366	0
49	CCAFS SLC-40	28.563197	-80.576821	1
50	CCAFS SLC-40	28.563197	-80.576821	1
51	CCAFS SLC-40	28.563197	-80.576821	1
52	CCAFS SLC-40	28.563197	-80.576821	1
53	CCAFS SLC-40	28.563197	-80.576821	1
54	CCAFS SLC-40	28.563197	-80.576821	1
55	CCAFS SLC-40	28.563197	-80.576821	1

Next, let's create markers for all launch records. If a launch was successful (`class==1`), then we use a green marker and if it launch was failed, we use a red marker (`class==0`)

Note that a launch only happens in one of the four launch sites, which means many launch records will have the exact same coordinate. Marks of such launch records will be in red if one of them is a failed one (containing many failures) having the same coordinate.

Let's first create a `MarkerCluster` object

```
# Create a marker cluster for the launch records
marker_cluster = MarkerCluster().add_to(site_map)
```

TODO: Create a new column in `launch_latlong` dataframe called `marker_color` to store the marker colors based on the `class` value

```
# apply a function
launch_latlong['marker_color'] = launch_latlong['class'].apply(lambda x: marker_color[x])
launch_latlong.tail(10)
```

	Launch Site	Lat	Long	class	marker_color
46	CCAFS LC-40	28.562302	-80.577366	0	red
47	CCAFS LC-40	28.562302	-80.577366	0	red
48	CCAFS LC-40	28.562302	-80.577366	0	red
49	CCAFS SLC-40	28.563197	-80.576821	1	green
50	CCAFS SLC-40	28.563197	-80.576821	1	green
51	CCAFS SLC-40	28.563197	-80.576821	1	green
52	CCAFS SLC-40	28.563197	-80.576821	1	green
53	CCAFS SLC-40	28.563197	-80.576821	1	green
54	CCAFS SLC-40	28.563197	-80.576821	1	green
55	CCAFS SLC-40	28.563197	-80.576821	1	green

TODO: For each launch result in `spacex_df` data frame, add a `folium.Marker` to `marker_cluster`

```
# Add marker_cluster to current site_map
site_map = marker_cluster.add_to(site_map)
# for each row in spacex_df data frame
# TODO: Create and add a Marker to the marker cluster
# Apply a function
# Make sure to add a marker to marker_cluster
# for i, row in spacex_df.iloc[:50].iterrows():
#
#
#
site_map
```

Your updated map may look like the following screenshots:

From the color-labelled markers in launch clusters, you should be able to easily identify which launch sites have relatively high success rates.

TASK 3: Calculate the distances between a launch site to its proximities

Next, we need to explore and analyze the proximities of launch sites.

Let's first add a `MousePosition` on the map to get coordinates for a mouse over a point on the map. As such, while you are exploring the map, you can easily find the coordinates of any points of interests (such as railway)

```
# Add mouse position to get the coordinate (long, lat) for a mouse over on the map
formatter = "function(num) {return L.Math.formatNum(num, 5);}";
mouse_position = MousePosition(
    position='topright',
    separator=' Long: ',
    empty_string="Generating...",
    lng_first=False,
    num_digits=20,
    prefix='Lat:',
    lat_formatter=formatter,
    long_formatter=formatter,
)
site_map.add_child(mouse_position)
site_map
```

Now, zoom in to a launch site and look for the closest railway, highways, and coastlines, while hovering from Mousepos coordinates. Notedown the coordinates of the closest railway, highway, and coastline. Hint: You may need to calculate the distance between these coordinates in order to see if it is a close one or not. For example, if you find a railway that is very close to the launch site, you may need to calculate the distance between the railway and the closest railway station, to see if railway station is close enough to the launch site for easy transportation of rocket parts and other equipment. Similarly, you may need to calculate the distance between the closest highway and the closest town, or between the closest coastline and the closest city, to see if they are far enough for safety concerns. Note that there may not be a railway station, highway, or coastline very close to the launch site, in which case, you may need to find the closest one and see if it is close or far enough for safety concerns.

Your updated map may look like the following screenshot:

Now, zoom in to a launch site and look for the closest railway, highway, and coastline. Hint: You need to use `MousePosition` to find the their coordinates on the map first

A railway map symbol may look like this:

A city map symbol may look like this:

After you put distance library, find a proximity, and calculate distance, you may answer the following questions easily:

- Are launch sites in close proximity to railways?
- Are launch sites in close proximity to highways?
- Are launch sites in close proximity to coastline?
- Do launch sites keep certain distance away from cities?

Answer: Yes, Yes, Yes, and No.

Also please try to explain your findings.

Explanation: Launch sites tend to be close to railways, highways, and coastlines, while maintaining from distances cities. Railways and highways are essential for logistics. Launch sites require large amount of resources to be brought in and have many workers involved in the launch process. Coastlines provide safety for launches, as any failed launches will land in the ocean rather than on land. Launch sites tend to stay away from cities because it is safer by avoiding accidents in case of failed launches and to minimize the noise and disturbance to the surrounding population. Cities also have many people and infrastructure, which increases the risk of damage and casualties. Launch sites are often located in remote areas to ensure safety and minimize disruption to daily life. Overall, the decision to place a launch site involves a trade-off between accessibility, safety, and minimizing disturbance to the surrounding environment.

Next Steps:

Now you have discovered many interesting insights related to the launch sites' location using folium, in a very interactive way. Next, you will need to build a dashboard using Plotly Dash on detailed launch records.

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Change Log

Date (YYYY-MM-DD)	Version	Changed By	Change Description
2021-08-11	1.0	Yan Luo	Created new lab for course

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